2002

Impacts of Crop Rotation and Nitrogen Fertilization on Crop Production

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Abstract
Crop yield usually is affected by the crop sequence used. Crop growth characteristics, type of harvested product, and management practices influence physical and chemical properties of soil, availability of water, and incidence of diseases, weeds, and pests. Increased soil nitrogen (N) availability, when legumes are included in the rotation, and reduced incidence of diseases and pests are two of the most important benefits of crop rotations.

Keywords
Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

Impacts of Crop Rotation and Nitrogen Fertilization on Crop Production

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Introduction

Crop yield usually is affected by the crop sequence used. Crop growth characteristics, type of harvested product, and management practices influence physical and chemical properties of soil, availability of water, and incidence of diseases, weeds, and pests. Increased soil nitrogen (N) availability, when legumes are included in the rotation, and reduced incidence of diseases and pests are two of the most important benefits of crop rotations.

A crop rotation study was begun in 1954 to observe effects on crop yield of seven cropping sequences and various N fertilization treatments. Some treatments changed over time until 1984; but since then, they have remained the same.

Current crop sequences are shown in Table 1. The N treatments are 0, 80, 160, and 240 lb N/acre and are applied only for corn. N fertilizer is applied in spring or fall for continuous corn, and in spring for all other rotations. Granulated urea is incorporated by plowing or field cultivating. Oats are always undersown with alfalfa. No hay is harvested in the seeding year, and three harvests generally are made in other years. Alfalfa hay yields for Rotation 5 (one year) and Rotation 6 (two years) are not shown in this report.

Summary Results

Corn yields. Continuous corn responded up to the highest N rate used (240 lb N/acre), but the additional response over the 160–lb rate would not have offset additional N costs in all seasons. There is a clear advantage for spring N application. For example, during the last four years, 80 lb/spring-applied N was, on average, almost as effective as 160 lb/fall-applied N. This average difference must be considered carefully, however, because it varied markedly across seasons and N rates and because the N source was urea. Incorporated urea is rapidly transformed by soil enzymes into ammonium, which, in turn, is nitrified to nitrate by soil microorganisms. Nitrification is fast in warm soils but very slow in soil temperature below 50°F. Nitrate cannot be retained by soil and is prone to leaching; so, when N fertilizer was applied late in the fall, early spring losses of N likely were high.

Yields of corn following soybeans, oats, or one year of alfalfa usually were maximized by the 160 lb N/acre rate. Rates lower than 80 lb N/acre could have been justified for corn following two years of alfalfa. More N was available in the soil after oats or forage legumes, as was confirmed by soil samples collected in late spring. When prevailing grain and N prices are considered together with the response to N, it becomes obvious that rates between 80 and 160 lbs N/acre could be justified for first-year corn after soybeans, oats, or one year of alfalfa. Producers should study their own N costs because costs vary with the N source and method of fertilizer application.

Rotating corn with other crops increased corn yield compared with yield of continuous corn, even at highest N rates. This additional benefit of the rotation is the result of improved physical properties of soil and fewer incidences of weeds, diseases, and pests.

Yield of soybeans and oats. Oats always responded to N fertilizer applied to the preceding corn crop except when it was planted after only one year of corn, preceded by two years of alfalfa. Results suggest that in most years either no N fertilization or a low rate of N fertilization would be adequate for oats grown after a well fertilized corn crop. Yields of soybeans or alfalfa hay were not affected by the N rate applied to the preceding corn crop.

Rotation effects were not observed for alfalfa but were significant for soybeans and oats. Yields of soybeans were lower for the corn–soybean rotation compared with those for Rotation 4, which included another year of corn and one year of oats undersown with alfalfa. Yields of oats were higher for the rotations that included one year or two years of alfalfa, compared with rotations that included only corn, or corn and soybeans.

Conclusions

Including soybeans, oats, or alfalfa in crop rotations increases corn yield and reduces the need for N fertilizer. Additional benefits of crop rotation include reduced pest control costs for some of the crops. Soybeans do not benefit from N applied to a preceding corn crop, but yields are increased when more than one corn crop or oats is included in the rotation. The overall profitability of these rotations can be fully assessed only after considering a variety of production costs and marketing opportunities that are beyond the scope of this report. Comparison of spring and fall N application showed that the fall application was much less efficient, which is important for crop production and environmental protection purposes.

Table 1. Rotation and N fertilizer effects on corn yield over 17 years and for the last 4-year period.

		17-Year Average Yield				Recent 4-Year Average Yield			
Rotation	Crop	0 N	80 N	160 N	240 N	0 N	80 N	160 N	240 N
		bu/acre							
1	Corn with spring N	56	113	138	149	66	133	154	160
7	Corn with fall N	53	97	126	136	65	108	135	144
2	Corn (first)	129	154	159	162	151	173	180	176
	Corn (second)	74	128	147	158	86	145	179	181
	Corn (third)	68	109	138	145	73	120	161	162
	Oats	51	61	68	71	62	75	83	79
3	Corn	102	141	159	163	111	149	171	172
	Soybean	44	45	45	44	54	54	53	53
4	Corn (after oats)	131	156	163	162	145	175	182	176
	Soybean	48	49	48	47	57	58	57	56
	Corn (after soybeans)	106	151	163	167	100	164	178	182
	Oats	52	62	70	74	66	74	84	86
5*	Corn after one year of alfalfa	149	157	161	164	169	174	184	191
	Corn (second)	103	136	155	160	117	148	175	173
	Oats	58	68	67	70	73	78	77	84
6*	Corn after two years of alfalfa	157	158	164	161	178	185	184	185
	Oats	75	72	76	74	95	87	93	91

* Yields of alfalfa after oats are not shown (one year for Rotation 5 and two years for Rotation 6).